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NEARSHORE DISPOSAL: ONSHORE SEDIMENT TRANSPORT,(U)
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NEARSHORE DISPOSAL: ONSHORE SEDIMENT TRANSPORT

Robert K. Schwartz and Frank R. Musialowski[1]

ABSTRACT

New dredge-disposal techniques may serve the dual role of aiding: (1) sand bypassing across coastal inlets, and (2) beach nourishment provided that dredged sediments placed seaward of the surf zone move shoreward into that zone. During the summer of 1976, 26,750 m^3 of relatively coarse sediment was dredged from New River Inlet, N.C., moved downcoast using a split hull barge, and placed in a 215 m coastal reach between the 2 m and 4 m depth contours. Bathymetric changes on the disposal piles and in the adjacent beach-nearshore area were studied for a thirteen week period to determine the modification of the surrounding beach-nearshore profile and the net transport direction of the disposal sediment.

The sediment piles created an initial local shoal zone with minimum depths of 0.6 m. Disposal sediment was coarser (Mn = 0.49 mm) than native sand at the disposal site (Mn = 0.14 mm) and coarser than the composite mean grain size of the entire profile (Mn = 0.21 mm). Shoaling and breaking waves caused rapid erosion of the pile tops and a gradual coalescing of the piles to form a disposal bar located seaward (≈ 90 m) of a naturally occurring surf-zone bar. As disposal bar relief was reduced, the development of disposal bar-associated breaker zones became more restricted to low tide periods or high wave conditions.

The disposal bar eventually migrated landward, in some cases at an average rate of 1.8 m/day, although movement appeared to be sporadic and to coincide most directly with periods of increased wave activity. With development of the disposal bar, the inner surf-zone bar was displaced landward. Sediment, some similar in appearance to disposal sediment, began to fill the inshore surf-zone trough. The trough downdrift from the disposal site also became choked with this type of material, evidencing longshore transport. In some cases, accretion occurred along the lower seaward flank of the disposal bar, possibly as a result of slope adjustment and seaward transport.

Final surveys showed accretion at the base of the foreshore, complete filling of the trough, a platform or new trough at the initial surf-zone bar position, disappearance of the surf-zone bar, and generally a more seaward surf zone boundary. Profiles adjacent to the disposal area showed slight accretion seaward of the surf zone. The

[1]Geologists, Geotechnical Engineering Branch, Coastal Engineering Research Center, Kingman Building, Fort Belvoir, Virginia 22060.

predominant transport direction of disposal sediment is interpreted to have been shoreward into the surf zone (in the direction of the coarsest native sand) and then in the direction of the longshore current. The increased width of the platform-disposal bar complex may provide benefits by increasing the amount of wave energy dissipation in the surf zone and hence, less erosion of the beach.

INTRODUCTION

The Wilmington District Corps of Engineers recently obtained a split-hull barge, named the "CURRITUCK", which has the capability of transferring sediment excavated from coastal inlet entrance channels to the shallow nearshore zone adjacent to the inlet. The CURRITUCK, when fully loaded, can release its load at a 2 m minimum water depth. This sediment transfer operation is conducted with the view that the placed or dumped materials will be transported by wave-induced currents to the beach and surf zones, thus aiding natural sand bypassing around the inlet and nourishing shores adjacent to the inlet complex, while also achieving the objective of maintaining desired navigation channel dimensions.

A test was conducted to examine both the operational effectiveness and sediment dispersal assumption for this type of disposal operation. This particular study, a part of the overall test, was designed to address the sediment transport factor, i.e., whether sediment placed in shallow coastal waters seaward of the surf zone will indeed move shoreward into the surf zone and onto the beach in response to natural processes. Bathymetric changes and textural properties of the beach-nearshore zone were studied to determine changes in the beach-nearshore profile, modification of the disposed material, the net transport direction of the disposal sediment, and the relative rate of disposal sediment movement.

The dredging site was located at New River Inlet, North Carolina (Fig. 1). The disposal area, the site for this study, was 2 km downcoast (southwest) from the inlet.

The CURRITUCK, at the time of this study, was loaded by means of a sidecasting dredge. Since then, the CURRITUCK has been modified to be self-loading. Future tests using the new dredge-barge combination will be conducted to examine the effects of disposing sand at different water depths, as well as the effects of varying oceanographic climate and season.

FIELD PROCEDURE AND DATA ANALYSIS

A 270 X 300 m area spanning the beach-nearshore zone was selected for making combined beach and nearshore profile measurements. The shore-normal dimension (300 m) extended from the base of the foredune (approx. +3 m MLW) seaward 240 to 270 m beyond mean low water (MLW) to an approximate water depth of -4 m MLW.

Fig. 1. Location of study area near New River Inlet, N.C.

During the period 19 July to 13 August 1976 (26 days), 26,750 cu m of sand were dredged from New River Inlet, transported to the disposal site by the CURRITUCK, and placed along a 210-meter coastal reach within the study area (Fig. 2). A 30 meter wide shore-normal zone, in which no sediment was to be placed, flanked both sides of the disposal reach. Some sediment, though, was inadvertantly placed within the southwest flank, between ranges -9+00 and -10+00, beyond the designed disposal limit. Although the CURRITUCK has a minimum water depth capability of about 2 m, a tidal range of about 1 m and varying swell conditions resulted in the actual disposal area extending from the 1.8 m to 4.0 m (MLW) depth contour. Monitoring of the study area began a week prior to disposal and extended through the disposal period until 19 Oct 76, 71 days following the final disposal date.

Profiles extending across the beach-nearshore zone were measured at 30 m intervals. The beach portion of each profile was measured using standard rod and tape surveying techniques. A stadia board attached to a towed, bottom-riding sea sled was used for obtaining bathymetric data seaward of the beach (Musialowski, Schwartz, and Teleki, 1977). The sled was towed seaward from the beach along a survey range line by an amphibious vehicle (LARC V), detached at an offshore point, and pulled landward by means of a shore-based winch. In several cases, the sled was towed slightly "off line" which led to outer profile variability involving the true position and shape of profile features. For this reason, data interpretation is based primarily upon shape and volume <u>trends</u>, not individual data points.

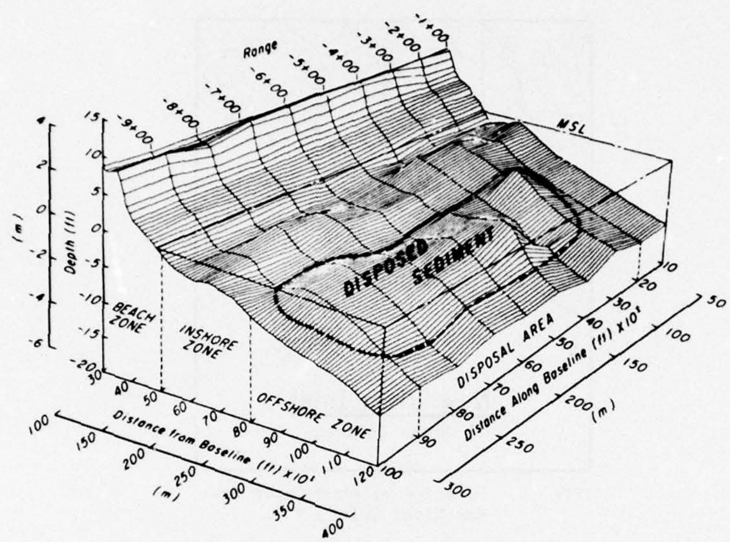

Fig. 2. Topography of the study area at the end of the disposal period.

Shore-parallel zones within the study area were defined for the purpose of examining profile shape and volume data. The area was divided into beach, inshore, and offshore zones (Fig. 2). The inshore zone spans the surf zone and consists of a trough, bar and seaward bar flank. The beach zone, containing the entire backshore and foreshore, extends seaward to about -1 m MLW. The inshore-offshore zone boundary is positioned on the seaward flank of the surf-zone bar between -1.5 and -1.8 m MLW. The offshore zone extends seaward to a point about 240 m beyond MLW (365 m from baseline) to maximum water depths of -4.5 m MLW. Although individual profiles were measured to more seaward distances, the 365 m baseline distance was common to all profiles and thus utilized as a seaward limit for purposes of mathematical treatment.

Sediment samples were collected from the upper 2 cm of the bed at 7.6 m (25 ft) intervals along a single profile line (-5+00) near the middle of the study area. The close sample spacing allowed textural representation of all dynamic zones and profile (shape) features. The sediment was sieved at a 0.25 phi interval using U.S. Standard Sieves. Statistics were calculated using the Inman equations (1952).

Longshore current velocity and direction, breaker height and period, angle of wave approach, and wind velocity and direction, were collected from 14 July through 16 September using Littoral Environment Observation (LEO) techniques (Bruno and Hiipakka, 1973). Aerial photography was used to document beach and disposal pile configuration and to examine nearshore circulation in the disposal area.

Profile data were edited for survey error and digitized to permit mathematical treatment. Volumes were calculated for 9.3 sq m (100 sq ft) areas between adjacent profiles using an elevation base of -6 m (MLW) and bottom elevations for each corner of the area.

PHYSICAL SETTING

The beach-nearshore zone prior to disposal contained a single bar which was shore-parallel, semi-continuous and located in the outermost part of the surf zone. In general, the beach-nearshore zone consisted of fine-grained ($Mn \approx 2.8$ phi, 0.14 mm), well sorted ($S\phi \approx 0.40$) sand.

The predicted tide range during the study period was mean = 1.0 m and spring = 1.1 m. The average breaker height ($\bar{H}_b$) was 0.55 m and average period of breaking waves ($\bar{T}_b$) was 7.3 sec. The experiment extended from a period of "summer oceanographic conditions" into a period of "winter oceanographic conditions." The summer oceanographic condition was characterized by southerly to southwesterly winds and a southerly swell direction. Winds during July were commonly diurnal with a low velocity breeze from the land in the morning and a higher velocity land-directed breeze in the afternoon. Breaker period was typically less than 6-7 seconds and breaker heights usually less than 0.6 m. The longshore current was northeast, toward the inlet, with an average measured speed of 18 m/min.

The winter oceanographic condition was characterized by northerly to easterly winds and a wave swell from the east. Breaker period was typically greater than 6-7 seconds and breaker heights commonly ≥ 0.6 m. Longshore currents were typically southwest at an average measured speed of 23 m/min. A number of northeasterly storms with wave periods > 8 seconds and breaker heights > 1.2 m occurred during September and October.

The disposal area, located about 2 km downcoast from New River Inlet, was judged to be beyond any direct influence of inlet-associated tidal currents.

DISPOSED SEDIMENT

Disposal Pile Characteristics

Upon release from the CURRITUCK, most of the disposed sediment dropped, with negligible spreading, to the ocean bottom to form a pile oriented in a shore-normal direction. A small amount of fine-sized sediment moved in suspension away from the pile. The slope of the

pile sides approached the angle of repose. Individual pile shapes were rectangular (∿ 25 by 40 m) with relief dimensions ranging up to 1.8 m. Piles were placed adjacent to and as close to each other as possible. A local shoal zone was created with minimum water depths of 0.6 m. The placed sand (composite mean = 0.49 mm) was coarser than the average size of native sand (mean ≈ 0.14 mm) at the point of disposal in the offshore zone as well as coarser than the composite grain size of the entire profile (composite mean = 0.21 mm).

Short-Term Modification of Disposal Piles

Under calm or minor swell conditions, the CURRITUCK would release sediment at an actual water depth of about 2 meters. Depending upon tide level, i.e., migration of the 2 m depth contour, and wave conditions, sediment was placed in a more landward or seaward position. The presence of the piles caused waves to deform locally and break over the new pile tops. Rapid erosion of the pile tops resulted. Waves broke on the more seaward-placed piles only during times of low tide. The landwardmost piles, i.e., those placed during high tide, were subjected to wave breaking at high tide, and rigorous surf-zone conditions during low tide. Wave activity on the piles decreased as pile relief decreased.

Wave and current reworking of the disposal piles resulted in a gradual coalescing of individual piles to form an asymmetrical disposal bar (steep side landward) located 60 to 90 m seaward of the naturally occurring surf-zone bar (Fig. 3). Although somewhat irregular in lateral distribution and topography, the disposal bar was oriented essentially shore parallel.

Small-scale (avg. length ($\bar{L}$) ≈ 9 cm, avg. height ($\bar{H}$) $\lesssim$ 1 cm), irregular to straight-crested ripples characterized the indigenous fine-sized bed of the disposal site. Larger scale ($\bar{L}$ = 25 cm, $\bar{H}$ = 5 cm), shore-parallel ripples developed in the coarse disposal sediment near the base of the disposal piles and in areas where disposal sediment spread laterally in the disposal zone. Some of the larger coarser-grained ripples were asymmetrical with the steep side in the landward direction.

MODIFICATION OF THE BEACH-NEARSHORE AREA BY NATURAL PROCESSES

Profile Shape

Offshore - The disposal bar eventually migrated landward, in some cases at an average rate of 1.8 m/day (Fig. 3). The rate of movement was sporadic varying in relation to the degree of wave activity. In general, as the disposal bar moved landward, its relief decreased and the bar shape became less prominant. During the 8 week survey period following disposal, the disposal bar did not reach the initial position of the natural surf-zone bar. Where the disposal bar approached the surf zone, the disposal-bar form was either eliminated or became rounded and much reduced in relief. In other cases, although the

disposal bar migrated onshore, it never reached this inner position.

Disposal sediment was not placed along three profile ranges (-1+00, -2+00, and -10+00) flanking the actual disposal area. Buildup in the offshore zone along these profile ranges would therefore be a result of natural accretion in response to sediment redistribution. For the three ranges, time-sequence profiles show essentially no change in shape of the offshore zone during the disposal period and initial post-disposal period (Fig. 4). The two ranges (-2+00 and -10+00) flanking to the disposed material (∿ 15 m away) show an eventual build-up of sand in the offshore zone later in the post-disposal period. Most of the buildup was southwest of the disposal site. The northeast profile range (-1+00), farthest from the disposed material (∿ 45 m), showed no accretion in the offshore zone throughout the study period.

Inshore - Inshore from the disposal bar, the surf-zone bar eroded or was displaced landward (Fig. 3). At the same time, the surf-zone trough filled with sediment and became part of the lower foreshore. A platform developed seaward through the surf zone extending to the

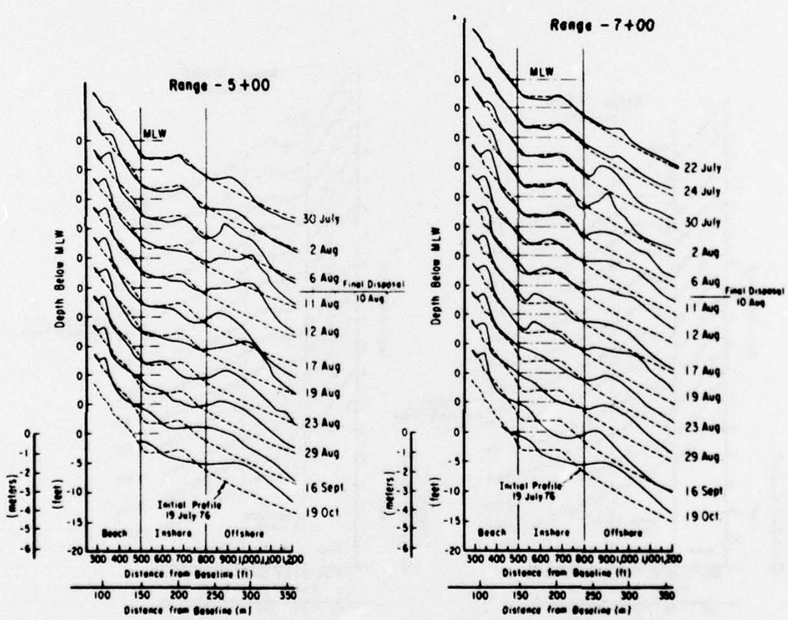

Fig. 3. Time-sequence of profile shape referenced to a predisposal survey (19 Jul 76). Ranges -5+00 and -7+00 were located within the disposal area.

encroaching disposal bar. This created a wider surf zone. In some cases, a new trough developed at the original site of the surf-zone bar. This new trough developed in association with, and immediately landward of, the encroaching disposal bar.

In the inshore zone northeast and southwest from the disposal sector, the surf-zone trough also filled (Fig. 4). In most cases, the surf-zone bar in these regions remained essentially stationary as the trough simply filled with sediment carried alongshore from the adjacent inshore zone of the disposal sector. At the southwest range (-10+00) a new trough was eventually cut at the surf-zone bar position after the initial trough had filled. This corresponded with a period of moderate storm conditions and high velocity longshore currents. This trough refilled and a small bar developed during the final month of study.

Beach - A low-amplitude ridge developed in the foreshore and migrated to the backshore along all profile ranges (Figs. 3 and 4). The size and relief of the bar initially increased, then decreased during migration. The time of initial ridge development varied according to position along the coastline. The ridge was in incipient form

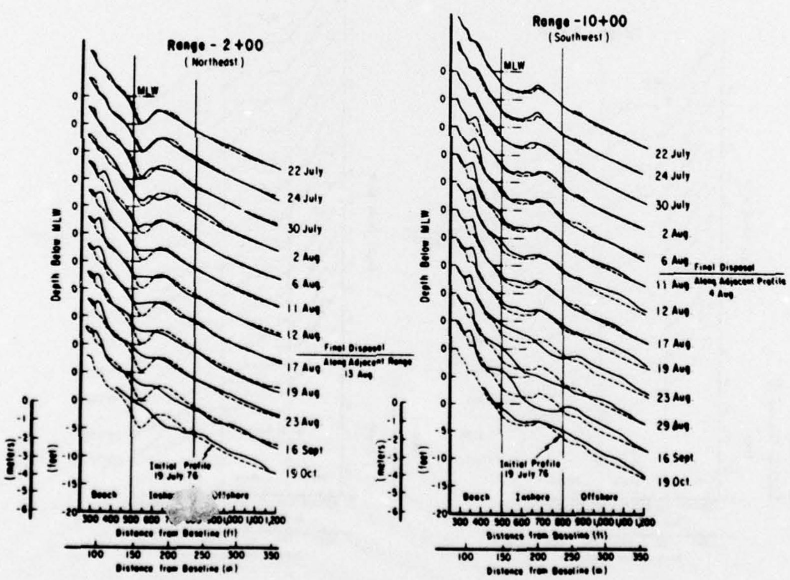

Fig. 4. **Time-sequence of profile shape referenced to a predisposal survey (19 Jul 76). Ranges -2+00 and -10+00 flank the disposal area.**

along the southwest ranges (-10+00 to -8+00) at the time of the pre-disposal survey (19 July). A ridge began to develop northeastward in the central beach ranges (-7+00 to -4+00) about four days later, and to develop farthest upcoast (-3+00 to -1+00) 10 to 11 days later. Genesis of the beach ridge is most likely related to a natural cycle of beach change (Hayes, 1977) and not the disposal operation. The ridge persisted throughout the time period in which beach surveys were conducted (average of 55 days).

Overall change in the foreshore was less apparent. In general, slight scour occurred in the intertidal zone, and accretion, associated with filling of the landwardmost margin of the trough, occurred in the subtidal zone.

Volume Change

General - Volume changes were examined for the offshore, inshore, and beach zones, as well as for subdivisions of each of those zones. All volume trends reflect sediment redistribution by natural processes, with exception of those for the offshore zone during the disposal period.

Offshore - Sediment volume in the offshore zone showed a strong net increase during the disposal period, a direct result of disposal in that zone (Fig. 5). Between 19 Aug and 16 Sep, a period of 28 days, there was a large volume decrease. Placement of sediment by mechanical means had ceased and net volume change was entirely a result of removal by natural processes. By 16 Sep, 75% of the 26,750 m^3 excess had been removed. Between mid-September and the end of the post-disposal period (mid-October), there was sediment buildup in the offshore zone, corresponding with the occurrence of storms.

To determine the direction of sediment movement, the volume change for subdivisions of the offshore zone was examined. Volume change for the actual disposal zone (ranges -2+00 to -9+00) versus those of the flanking northeast-offshore (-1+00 to -2+00) and southwest-offshore (-9+00 to -10+00) zones are shown in Figure 6. The northeast-offshore zone showed little overall change until 16 Sep, afterwhich slight accretion occurred ($\sim$ 690 m^3). The time-sequence plots of individual profile ranges show negligible change along the most northeastward range (-1+00) with only slight buildup along the adjacent range (-2+00) (Fig. 4).

The southwest-offshore zone shows a greater volume increase than the upcoast zone (Fig. 6). This volume trend is partially a result of mechanical placement of disposal sediment slightly beyond range -9+00. However, natural buildup in this offshore zone is also indicated by continued accretion during the post-disposal period. Although no sediment was mechanically placed along range -10+00, the southwestern limit of the study area, time-sequence profiles and area calculations for those profiles show offshore accretion. The greater amount of offshore accretion in the southwest direction rather than the northeast direction corresponds with a predominance of waves and longshore currents toward the southwest during the post-disposal period.

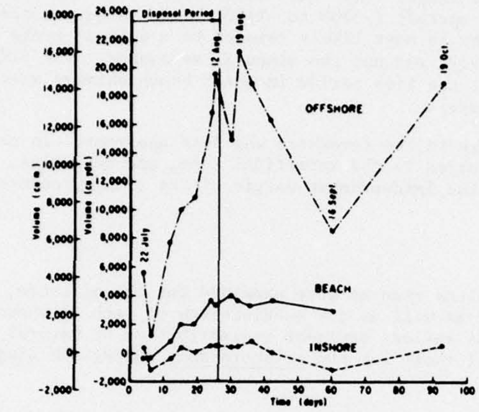

Fig. 5. Volume change through time for beach, inshore and offshore zones. Data points for Figs. 5 and 6 represent the difference in volume between a pre-disposal survey (19 Jul 76) and successive surveys.

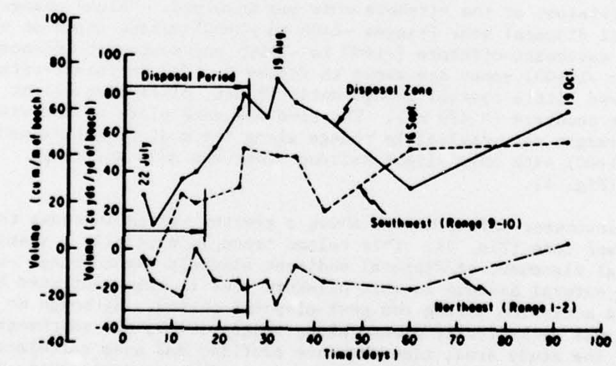

Fig. 6. Volume change in the offshore zone for the disposal area and flanking northeast and southwest areas.

The offshore disposal zone was also partitioned into 30 meter wide shore-parallel sub-zones (Fig. 7F-I) and as in the case of volume change for the entire offshore zone (Fig. 5), all of the offshore sub-zones experienced accretion during the disposal period (mechanically placed sand), erosion during the first half of the post-disposal period (natural processes), and accretion in the second half of the post-disposal period (natural processes). Of particular importance is the sequential offset of accretion peaks (maxima) in the volume trends for adjacent subzones during the early post-disposal period (Fig. 7F to 7H, time period 26-42 days). In general, the volume-peaks shift in the direction of increasing time for adjacent landward subzones suggesting that a volume of sediment, or more specifically, the position of maximum sediment buildup, migrated landward with time. Such a trend correlates with onshore migration of the disposal-bar form. In addition, the duration of maximum accretion for the most landward sub-zone (Fig. 7F, day 30-42) is longer than for other sub-zones and is followed by a lower erosion rate, possibly indicating this innermost subzone was, at least in part, nourished by the more seaward sub-zones.

Inshore - Volume changes for the inshore zone are similar in trend to those of the offshore zone, but of lower magnitude (Fig. 5). The accretion trend during the disposal period, though, is totally a result of natural buildup. This overall buildup continues into the early post-disposal period. Net erosion within the zone occurred until late in the post-disposal period, when storm-associated buildup reoccurred.

The inshore zone contains the surf-zone bar and trough. The time-sequence profiles show that these elements underwent significant modification following disposal. Volume changes were plotted for the three, 30 meter wide, shore-parallel sub-zones comprising the inshore zone (Fig. 7C, D, E). These sub-zones correspond to the predisposal trough, surf-zone bar, and bar flank position. Volume trends for the sub-zones reflect the shape modification of each profile element. The trough filled and the bar eroded at a high rate during the last of the disposal period and early post-disposal period. Later in the post-disposal period, volume change in the initial bar and trough positions was minimal and remained that way throughout the study period.

Beach - The beach accreted during the disposal period to the early post-disposal period, then showed slight erosion. Overall, there was net accretion for the entire period of beach measurement. Volume change for sub-zones of the beach show greater buildup in the backshore than the foreshore. Overall buildup of the backshore, including a slight volume decrease with time, corresponds to development and migration of the beach ridge. The net buildup of the foreshore sub-zone is related to infilling of the inner margin of the trough, which is included in that general sub-zone.

Textural Change

The predisposal profile was characterized by a textural trend in which sand sizes fined seaward from a medium-sized sand on the backshore to a very fine-sized sand along the outermost profile (Fig. 8). Three zones of local coarsening occurred within this overall trend.

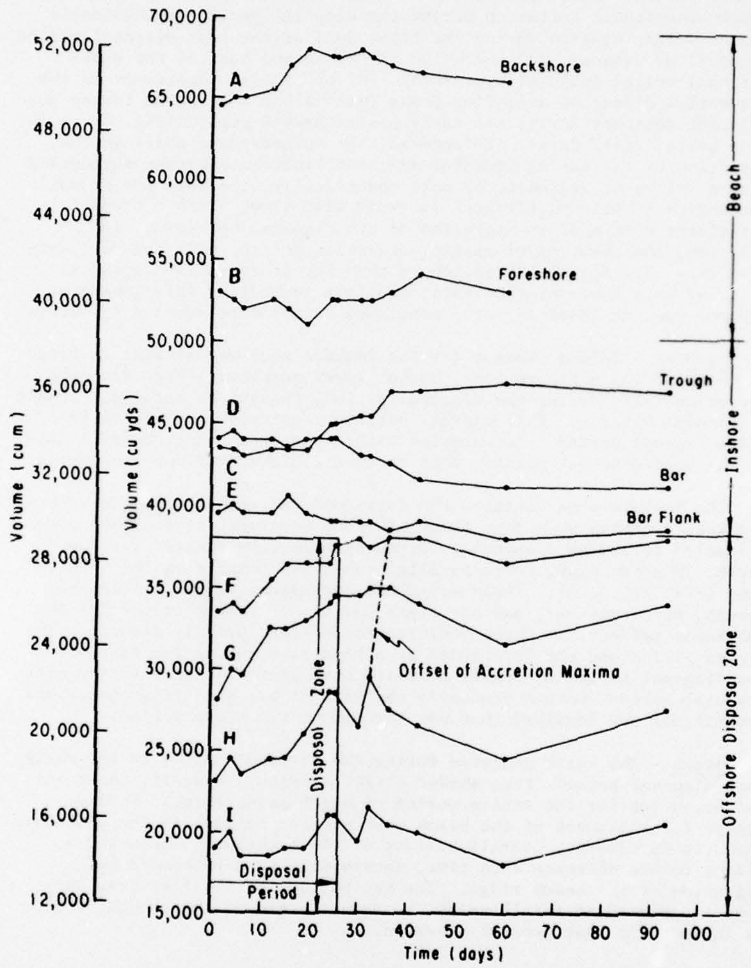

Fig. 7. Volume through time for 30 m (100 ft) wide shore-parallel sub-zones of the beach (A, B), inshore (C, D, E), and offshore areas (F, G, H, I) of the disposal sector. In the offshore zone, sub-zones F through I are in sequential seaward locations.

The zone of coarsest material, with grain sizes ranging into the coarse-sand class, was associated with the swash-zone. The two other zones, showing only a slight coarsening, occurred in the trough and just seaward of the surf zone. Poorer sorting values were associated with the coarser sand in the swash zone and seaward of the bar.

Following sampling of the pre-disposal profile, dredged sediment was placed in what was then the upcurrent direction (southwest) for that time period. Placement was $\geq$ 15 m away from the sampled profile near profile range -6+00 (Fig. 8). No sediment was placed along the

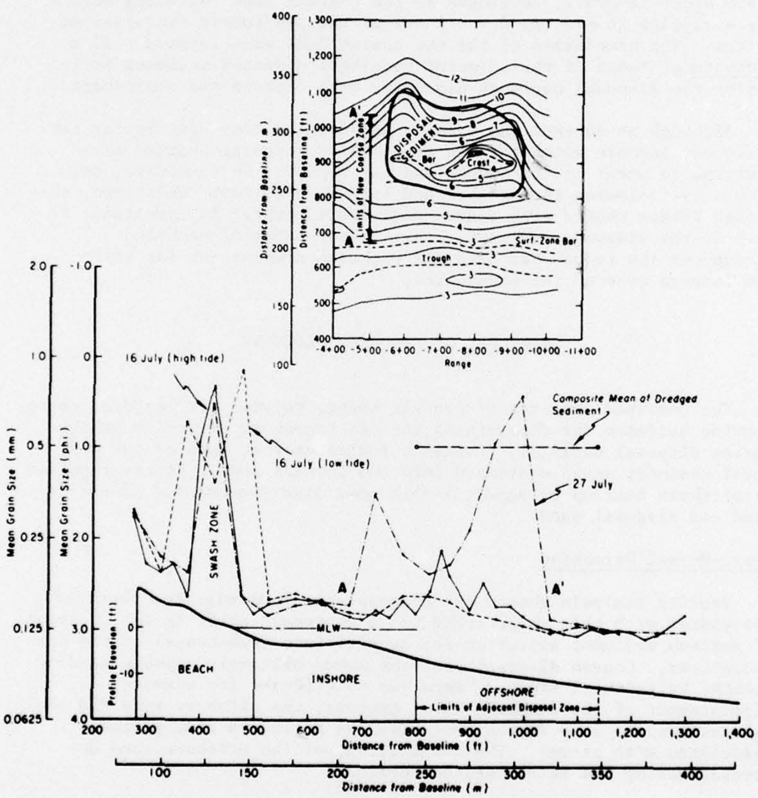

Fig. 8. Mean grain size across profile range -5+00. The inset map shows the location of placed sediment and the position of the resultant coarse zone (A-A') along range -5+00.

previously sampled native profile. The disposal sediment was coarser (composite Mn = 1.04 phi, 0.49 mm) (Fig. 8) and less well sorted (composite S_ϕ = 1.02) than the native sand. The disposed sediment was texturally most similar to the coarse, poorly sorted sediment of the swash zone.

Seven days following sediment disposal, the profile was resampled. A coarse textural anomally had developed across part of the earlier fine-grained inshore and offshore zones (Fig. 8). This new coarse zone was characterized by fine- to coarse-grained, poorly sorted sand. Relatively large ripples ($\bar{L}$ = 25 cm, $\bar{H}$ = 5 cm), some asymmetrical with steep sides landward, developed in the coarser zone replacing small-scale ripples ($\bar{L}$ = 5 cm, $\bar{H}$ = < 1 cm) of the previously fine-grained bottom. The boundaries of the new coarse zone were located ∿ 30 m landward of those of the adjacent upcurrent disposed sediment indicating the disposal sediment had moved both onshore and alongshore.

Although no attempt was made to measure sediment texture for the beach and inshore zones through time, major textural changes were observed to occur in the trough and bar region. On some days, particularly following strong surf and longshore current conditions, the trough became choked with coarse sediment identical in appearance to that of the disposed sediment. This coarse material occurred throughout the trough-bar area and extended downcurrent far beyond the inshore zone of the study area.

TRANSPORT OF DISPOSED SEDIMENT

The combined data set of profile shape, volume, and textural change provide evidence for determining the net transport direction of the coarse disposal material. Evidence indicates that most of the disposal sediment moved shoreward into the inshore zone. Storms resulted in offshore buildup of material that most likely consisted of native sand and disposal sand.

Shore-Normal Direction

Profile analysis showed the disposal-bar form migrated shoreward. Associated with this shape trend was a shoreward shift in the location of maximum sediment accretion for subdivisions (sub-zones) of the offshore zone. Coarse disposal sediment moved obliquely onshore as documented by textural study. There was no evidence for seaward displacement of the disposal bar. However, the offshore zone did show general buildup late in the post-disposal period, a time period associated with storms. The total volume of the offshore zone decreased during the fairer weather periods.

As the disposal bar moved shoreward and the total offshore volume decreased, the inshore zone and beach showed overall accretion. The surf-zone bar was displaced landward or eroded, and the trough filled. Coarse sediment similar in appearance to the disposed sediment was observed to spread throughout the inner bar-trough region. Although

disposal sediment was most likely added to the beach, development of the beach ridge was probably related to natural cyclic beach change.

Shore-Parallel Direction

Profile shape and volume data indicate only slight alongshore movement of disposal sediment out of the offshore-disposal area into the adjacent offshore zone. The inshore zone northeast and southwest of the disposal sector, however, experienced a high rate of trough filling. Longshore currents were observed to move much of the sediment along the entire inshore zone. Indeed, several times the coarse sediment filling the inshore zone of the sector was traced in the direction of the longshore current, and beyond the limits of the study area.

General Transport Pattern and Rate

The general transport pattern for the coarse grained disposal sediment was onshore (or shore-oblique) movement into the inshore and beach zones, then alongshore. This pattern is in accord with field-measured dispersal patterns for fine-grained to medium-grained radioactive sand tracers placed in the California nearshore zone (Duane, 1976; Schwartz, 1976).

Six days following final disposal, 40% of the 26,750 m^3 excess amount had been removed from the offshore zone, and 75% had been removed by 34 days after disposal, an average loss rate of $\sim$ 340 m^3/day. Evidence indicates that most of the loss had been shoreward into the inshore and beach zones. In relation to the placed 26,750 m^3excess, the beach showed a 10% gain 6 days after disposal and an 8% gain 34 days after disposal. The inshore zone initially showed a 1.5% gain (6 days post-disposal) followed by a slight volume decrease. Accretion in the beach and inshore zones does not balance the amount of offshore loss, thus indicating loss from the study region.

Measured volume changes for any zone in an open system may not be indicative of the real volume transport through that zone. The higher the transport rate, the less reliable is volume change as a measure of that rate. Tracer data for the California nearshore zone show that longshore transport rates are highest for what would correspond to the inshore zone of this study, next highest for the beach zone, and lowest for the offshore zone (Duane, 1970). In addition, bed load sediment which enters the inshore zone tends to remain in that zone unless moved seaward, by rips, or onto the beach (Schwartz, 1976). Although sediment may enter the inshore zone from the offshore zone at a high rate, it may also move downcoast within the inshore zone at a high rate.

Although the foreshore showed little change in shape, net accretion occurred landward on the backshore and seaward in the trough. Once sediment moves landward beyond the foreshore, the probability of entrainment and removal is much reduced. A longer residence time is thus expected for particles moved onto the beach than for those moved into the inshore zone. This explains the greater net volume gain for

the beach in the study area even though it is known that a greater volume of disposal sediment entered the inshore zone.

Although much sediment entered the combined beach-inshore zone, field measurements strongly indicate that most of the incoming sediment moved alongshore nourishing the adjacent beach and inshore zones.

CONCLUDING REMARKS

The results of this experiment are encouraging with respect to the concept of sand bypassing and beach nourishment using a split-hull type barge. Dredged material placed in the zone between the 2 m and 4 m depth contours was moved, by natural processes, landward into the beach and innermost littoral zones. For example, in 34 days following final placement, 75% of the total disposal volume had been removed from the disposal site. However, a relatively small portion of the total amount that was placed could be accounted for in the surveyed beach and inshore zones. The longshore current was of major importance in moving the disposal material once it reached the surf zone. Instead of continuing to move shoreward onto the beach, much of the sand was deflected and eventually moved in a longshore direction, feeding the downcoast littoral zone and beach areas.

Disposal piles were modified soon after placement to form a bar which eventually migrated landward. The relief of the bar and the volume of sediment contained in it decreased during its landward migration, and by the time the bar reached the surf zone its shape was lost or greatly diminished.

With landward migration of the disposal bar, removal of the natural surf-zone bar, and filling of the inshore trough, a platform was created which widened the surf zone. In some cases, a new trough was cut in this platform at the initial surf-zone bar position. The development of such a platform may serve to provide additional beach protection benefits by increasing wave energy dissipation in the surf zone. Wave refraction around the disposal zone may also promote sediment accretion landward of the zone, as in the case of offshore breakwaters.

Survey coverage permitted an evaluation of bottom changes for a distance of 60 m seaward of the disposal site. In a single case, between 16 September and 19 October, a period during which a number of moderate coastal storms occurred, the offshore area gained sediment, apparently from the beach and inshore zone. This points out the importance for the timing of offshore disposal relative to seasonal wave energies and is an important consideration in predicting which way the disposal sediment will move, i.e., the autumn and winter storm season will more likely result in a portion of the sediment being moved seaward than less stormy spring and summer periods.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

New dredge-disposal techniques may serve the dual role of aiding: (1) sand bypassing across coastal inlets, and (2) beach nourishment provided that dredged sediments placed seaward of the surf zone move shoreward into that zone. During the summer of 1976, 26,750 m of relatively coarse sediment was dredged from New River Inlet, N.C., moved downcoast using a split hull barge, and placed in a 215 m coastal reach between the 2 m and 4 m depth contours. Bathymetric changes on the disposal piles and in the adjacent
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beach-nearshore area were studied for a thirteen week period to determine the modification of the surrounding beach-nearshore profile and the net transport direction of the disposal sediment.

The sediment piles created an initial local shoal zone with minimum depths of 0.6 m. Disposal sediment was coarser (Mn = 0.49 mm) than native sand at the disposal site (Mn = 0.14 mm) and coarser than the composite mean grain size of the entire profile (Mn = 0.21 mm). Shoaling and breaking waves caused rapid erosion of the pile tops and a gradual coalescing of the piles to form a disposal bar located seaward ($\approx$ 90 m) of a naturally occurring surf-zone bar. As disposal bar relief was reduced, the development of disposal bar-associated breaker zones became more restricted to low tide periods or high wave conditions.

The disposal bar eventually migrated landward, in some cases at an average rate of 1.8 m/day, although movement appeared to be sporadic and to coincide most directly with periods of increased wave activity. With development of the disposal bar, the inner surf-zone bar was displaced landward. Sediment, some similar in appearance to disposal sediment, began to fill the inshore surf-zone trough. The trough downdrift from the disposal site also became choked with this type of material, evidencing longshore transport. In some cases, accretion occurred along the lower seaward flank of the disposal bar, possibly as a result of slope adjustment and seaward transport.

Final surveys showed accretion at the base of the foreshore, complete filling of the trough, a platform or new trough at the initial surf-zone bar position, disappearance of the surf-zone bar, and generally a more seaward surf zone boundary. Profiles adjacent to the disposal area showed slight accretion seaward of the surf zone. The predominant transport direction of disposal sediment is interpreted to have been shoreward into the surf zone (in the direction of the coarsest native sand) and then in the direction of the longshore current. The increased width of the platform-disposal bar complex may provide benefits by increasing the amount of wave energy dissipation in the surf zone and hence, less erosion of the beach.